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A320 A323 A326 A329
A339 A33Y A349 A34Y
A35Y A360 A362 A364
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A459 A509 A51Y A529
A533 A53X A53Y A557
A559 A55Y A562 A565
A568 A56X A571 A574
A577 A579 A57Y A584
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A591 A593 A595 A599
A59X A609 A615 A617
A619 A61X A61Y A621
A623 A625 A627 A629
A62X A671 A673 A675
A677 A679 A67X A681
A683 A685 A686 A687
A689 A693 A695 A697
A699 A69X A70X

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(56) Documents cited

GB 1371948

GB 1343013

GB 1271185

GB 1053271

GB 805266

GB 455531

GB 437744

GB 279414

(58) Field of search

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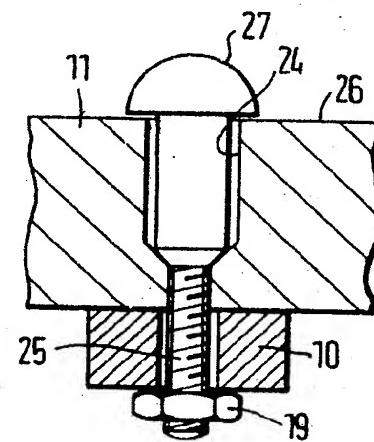
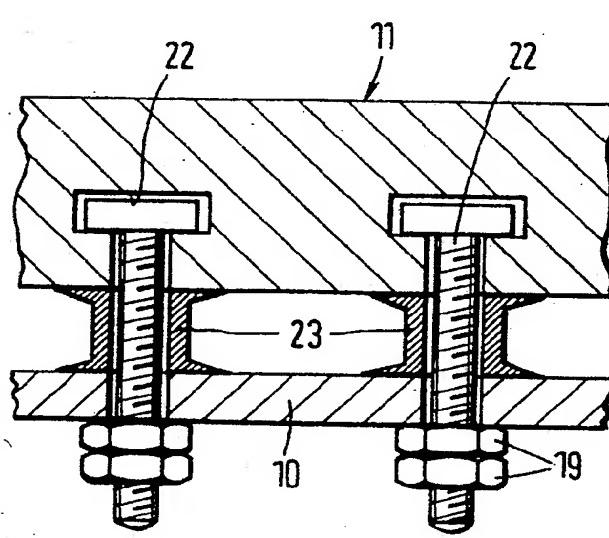
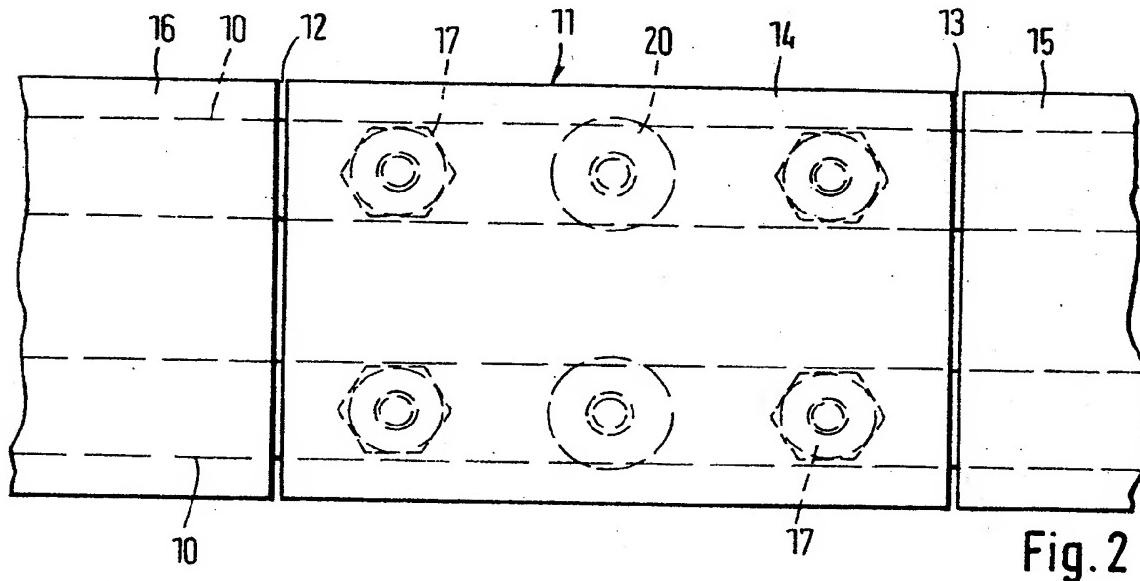
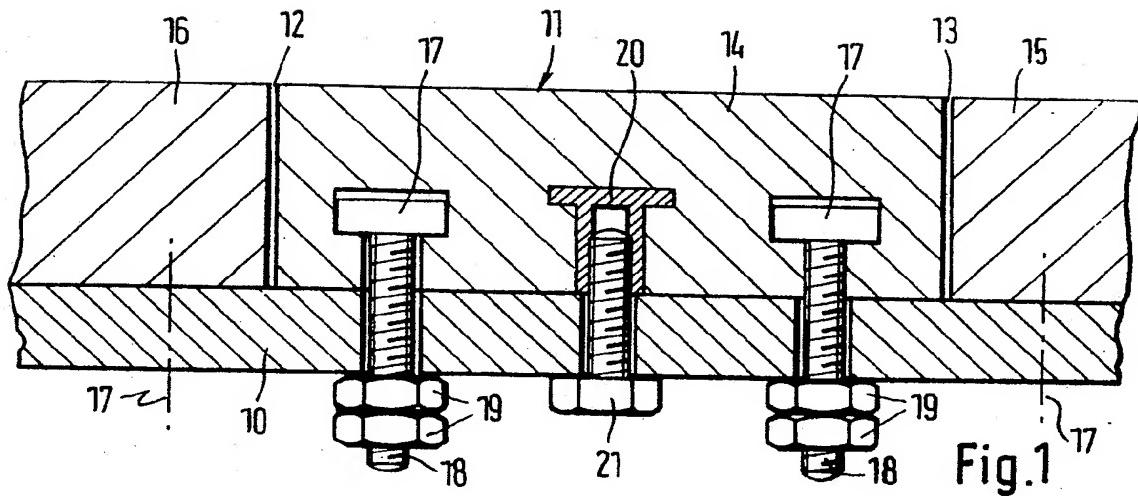
(54) Metallic or Composite Armour
(57) Armour plating consists totally or
partially of chilled cast iron material,

and may be of single-layered
construction or may consist of a
number of layers. The iron may
include inserts of tungsten carbide. In
one embodiment the object consists
of a tenacious underbody and an
overbody of chilled cast iron material
thereon. Numerous types of armour
construction are described and
illustrated.

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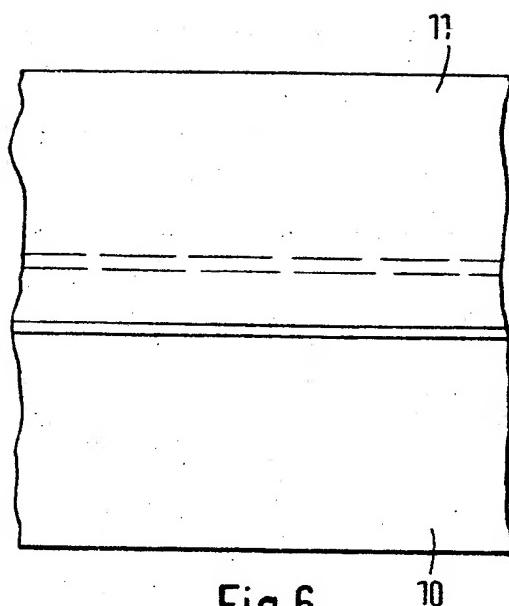


Fig. 6

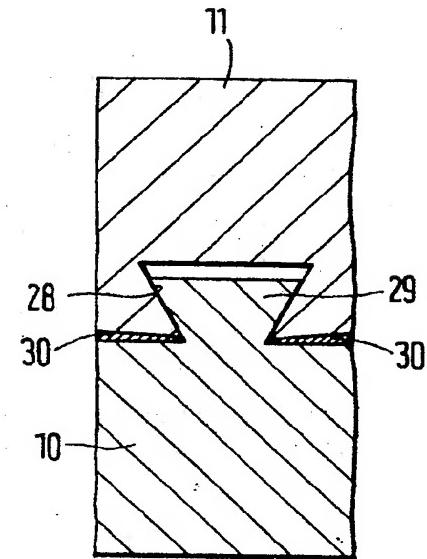


Fig. 5

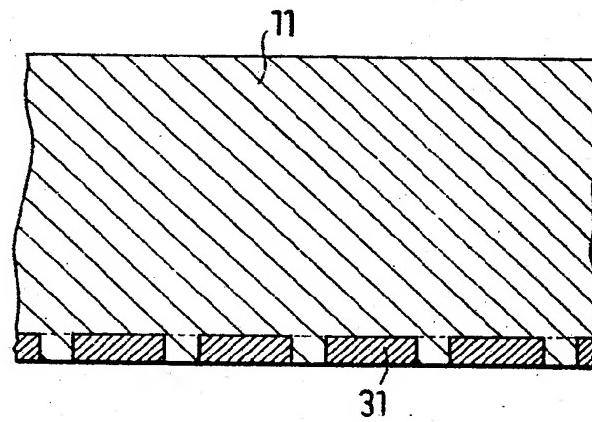


Fig. 7

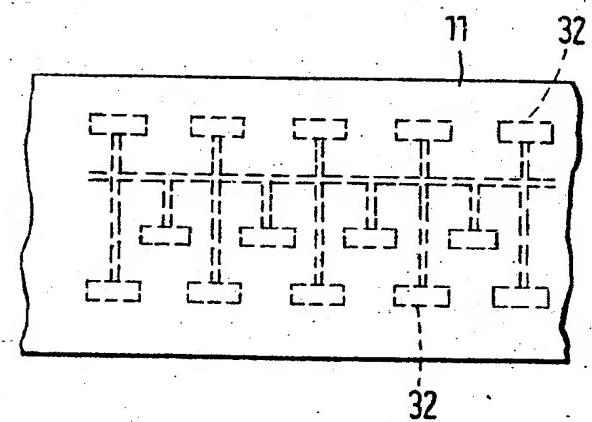


Fig. 8

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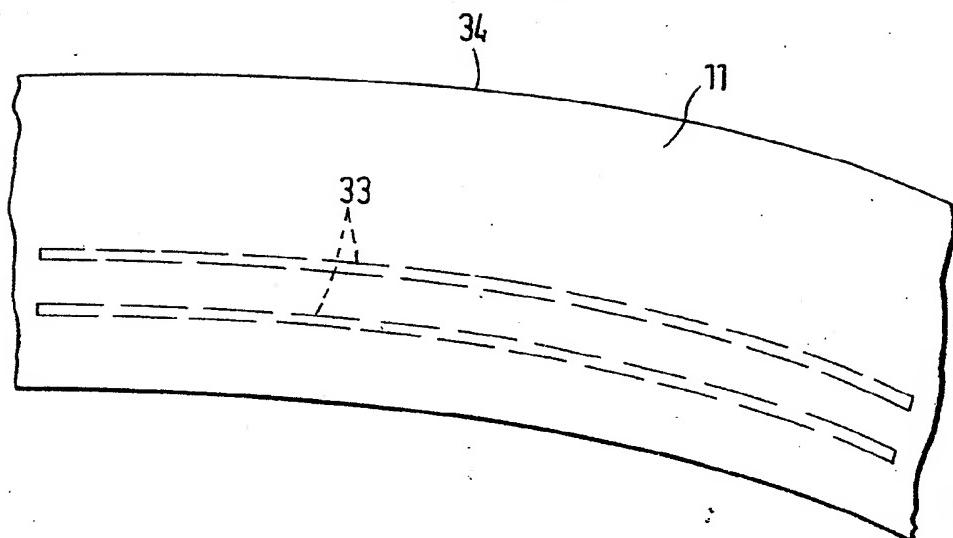


Fig. 9

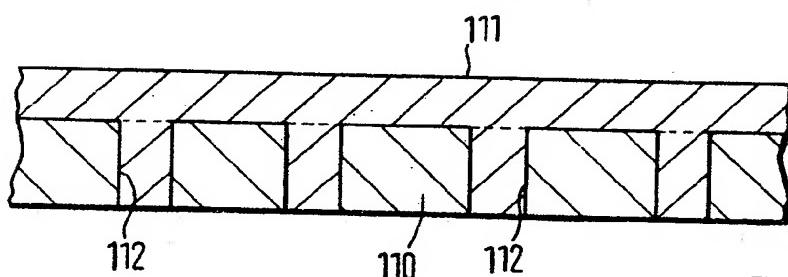


Fig. 10

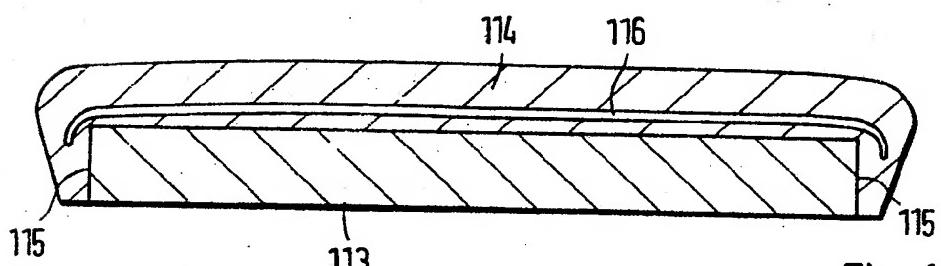


Fig. 11

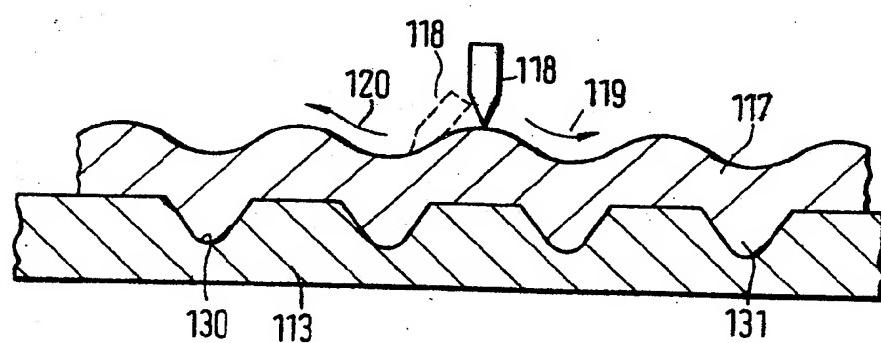


Fig. 12

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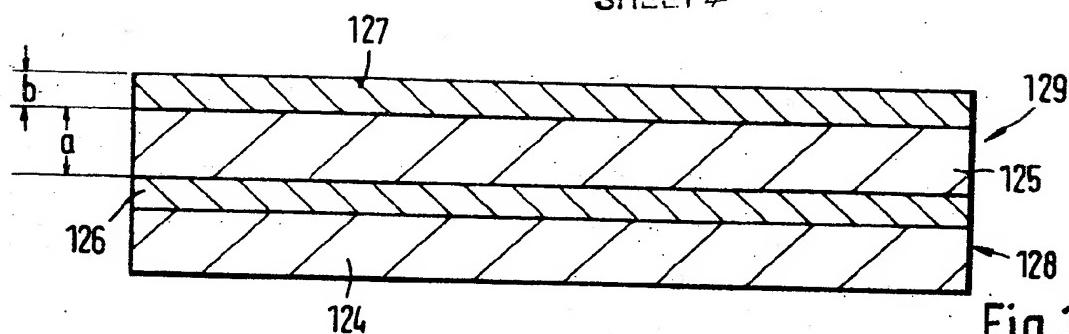


Fig.13

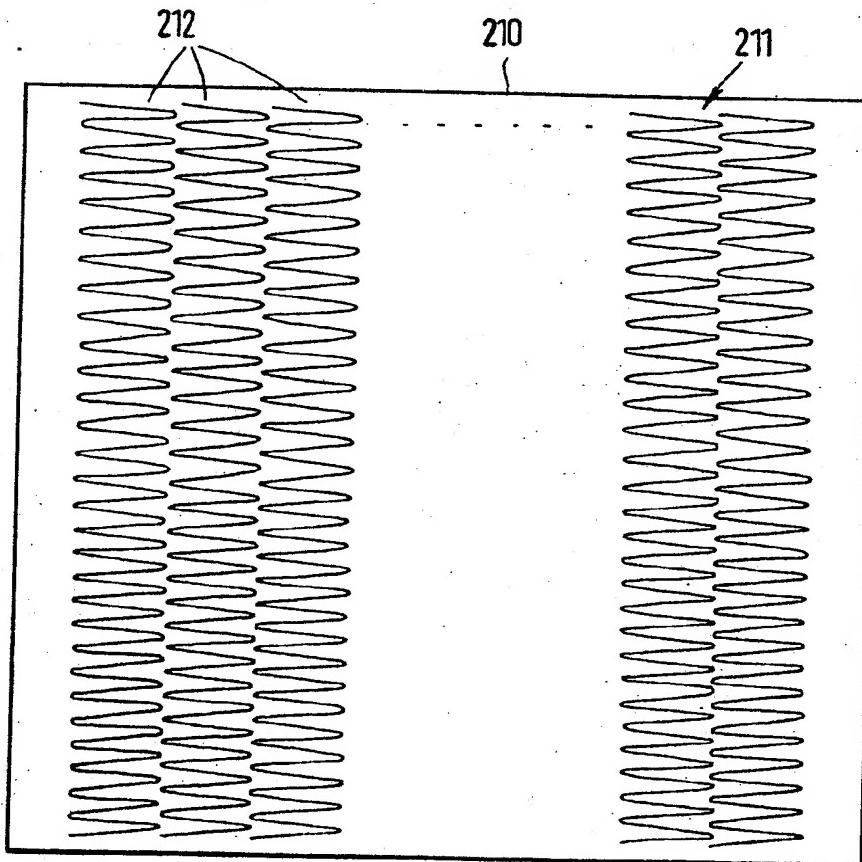


Fig.14

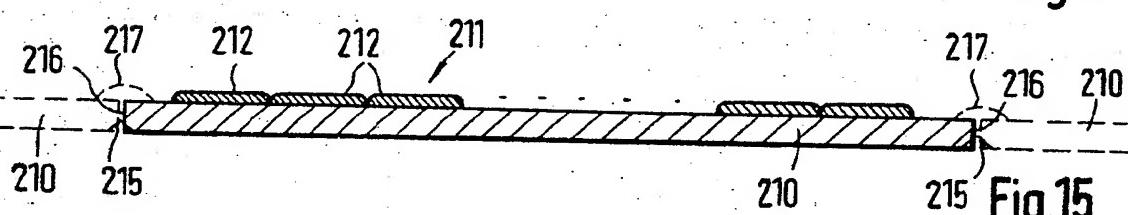


Fig.15

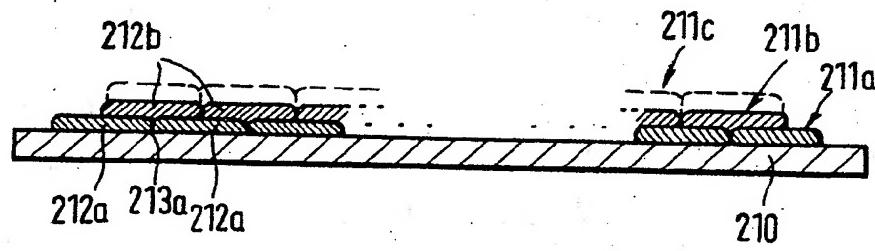


Fig.16

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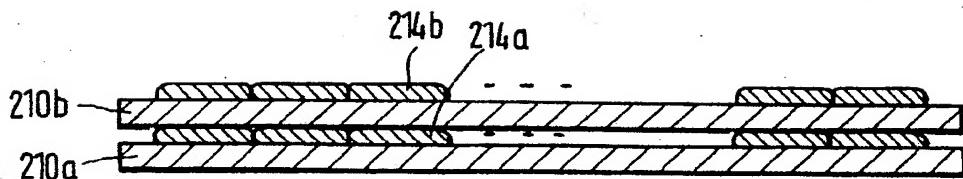


Fig. 17

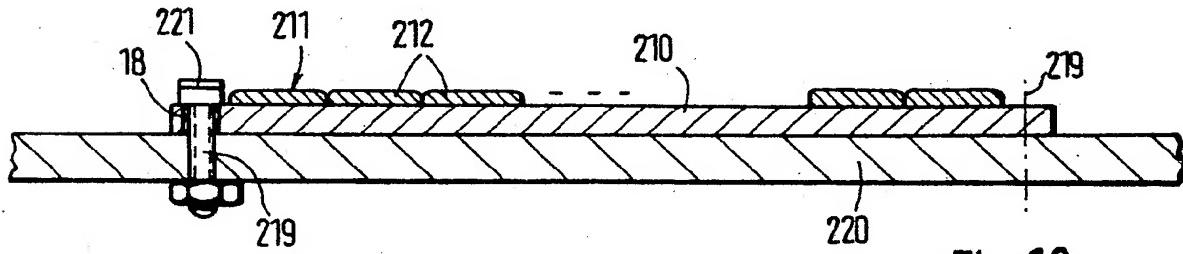


Fig. 18

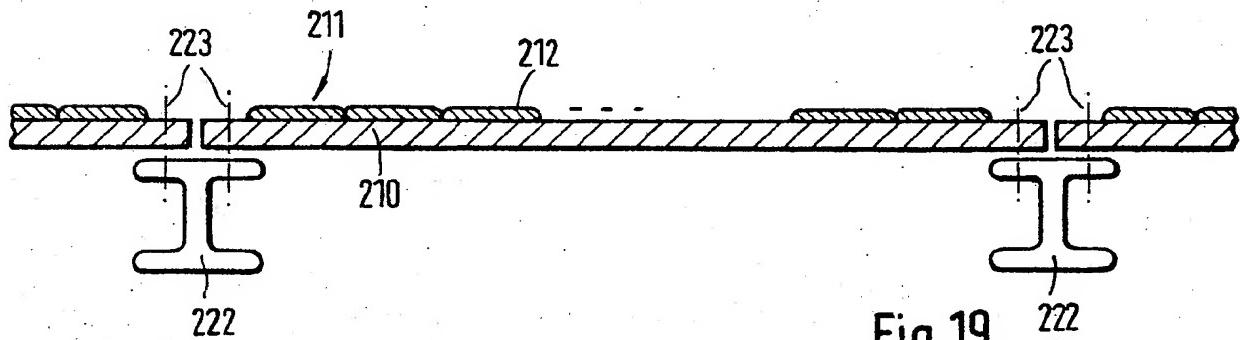


Fig. 19

SPECIFICATION
Bombardment-Proof Object

The invention relates to bombardment-proof objects. This refers more specifically to a plate-shaped object. However, the invention is not intended to exclude any other types of bombardment-proof objects. It is thus conceivable, e.g. to attach correspondingly angled or curved bombardment-proof objects to edges or corners 10 of objects which are to be protected.

Among armoured installations, a distinction is made between those which are bombardment-proof against *light* bombardment (rifle and machine-gun fire), and those which withstand 15 *heavy* or even *ultra-heavy* bombardment. Whereas objects required to be protected against light bombardment may include both military and civil installations, it is probable that exclusively military installations—e.g., armoured vehicles, 20 landing craft, gun shields etc., need to be afforded protection against heavy and ultra-heavy bombardment. In this context, heavy and ultra-heavy bombardment means bombardment by heavy guns, rockets and anti-tank projectiles.

One important field of application for 25 bombardment-proof objects, e.g., in the form of armour plates, is the protection of civil installations. In this context, special attention is drawn to the current wave of terrorism. To give 30 individual examples, the following may qualify for the application of bombardment-proof objects: armour of vehicle, aircraft or helicopters, armour of buildings and waterborne craft. Bombardment-proof objects of the type discussed here are also 35 required for other installations of a civil (or military) nature. For example, the following are extremely important fields of application: so-called object protection (buildings, window frames), individual protection (bodyguards to 40 important persons), power station protection (e.g. doors of power stations), bank protection (vaults, counter rooms, offices), motor car protection (here the lightest possible weight of the bombardment-proof objects plays a decisive role), 45 transport protection in armoured vehicles of all types (e.g. armoured scout cars), the protection of transport installations for important documents, cash consignments etc., and the protection of police vehicles.

The production of the high-grade armour steel 50 alloys hitherto known involves a high technical outlay which naturally involves high costs. Furthermore known steel plates have to be made extremely thick in order to ensure the required 55 immunity to bombardment, which in turn leads to increases in cost and furthermore to a disadvantageous increase in weight of the armoured installation, e.g., a vehicle.

Therefore the present invention seeks to 60 produce a bombardment-proof object which has a comparatively low weight together with a relatively high immunity to bombardment and a comparatively low production cost. At the same time a bombardment-proof object according to

65 the present invention is intended to be useful for the widest variety of applications in an economically justifiable manner.

According to one aspect of the present invention, there is provided a bombardment-proof 70 object, consisting totally or partially of chilled cast iron material.

The chilled cast iron material preferably has a Vickers hardness (HV 10) greater than 500.

The term chilled cast iron material is intended 75 here to mean iron-carbon based alloys with additional contents of Si, P, S and elements with an austenitic influence, e.g., Mn, Ni, Mo and substances forming special carbides, e.g., Cr, Mo, vanadium niobium, titanium, cerium, boron, in 80 which the predominant part of the carbon is present in the structure as carbide. Other hard substances, e.g., borides, may also be present in the structure.

The underlying aim of the present invention is 85 the incorporation of extremely hard alloy components (e.g., tungsten) in a relatively soft basic mass. However, fairly large bodies, preferably in the form of granules and/or inserts of tungsten carbide or of another hard material may 90 also be incorporated in the chilled cast iron material.

The bombardment-proof object is preferably composed of a plurality of individual members 95 consisting totally or partially of chilled cast iron material butt-jointed together. The bombproof-object may be of single-layered construction or consist of two or more superposed layers.

It is possible with the present invention to achieve a desired bombardment-resistance even 100 for a relatively small wall thickness, the weight and the manufacturing costs being therefore extremely low. Furthermore, the chilled cast iron material used can as such be produced and processed for a relatively small capital outlay.

In the case of a multiple-layered construction 105 of a bombardment-proof object according to the invention, the superposed layers may be attached to each other.

The bombardment-proof object may include a 110 tenacious underbody and an overbody of chilled cast iron thereon.

In this case it is possible to arrange the overbody loosely or substantially loosely upon the underbody or is attached only frictionally thereto.

Such a frictional joint between underbody and 115 overbody may be effected e.g., by screwing soldering or also pressing together by means of straps or the like.

In the case of a fracture of the bombardment- 120 proof object, which may nevertheless occur, in order to prevent its disintegration into numerous individual fragments, the bombardment-proof object may include rod-shaped steel inlays located movably within the chilled cast iron

125 material, the total weight of the said inlays being less than 5% of the total weight of the chilled cast iron material, and cast into the chilled cast iron material. The steel inlays may be movably within narrow limits in the chilled cast iron material and

preferably are less than 0.5% by weight of the total weight of the chilled cast iron material. The steel inlays may be arranged within the chilled cast iron material remote from the surface

5 arranged to be exposed to bombardment.

According to an embodiment of the invention which is suitable more particularly for heavy or ultra-heavy bombardment, the bombardment-proof object may consist preponderantly of chilled

10 cast iron. In this case it may be constructed of one or more layers.

According to another embodiment of the invention which is intended rather for light bombardment, the bombardment-proof object

15 may include a tenacious, preferably metallic, underbody and of an overbody made of chilled cast iron thereon. The overbody may be attached to the underbody over its entire surface of contact, so that the two parts form a composite object. The chilled cast iron material forming the overbody may be fixed on the underbody directly by casting. A particularly intimate connection between underbody and overbody is achieved according to a further embodiment of the present

20 invention where the underbody is a perforated plate, the surface of the underbody, and the holes therein into which the cast chilled cast iron material penetrates, fix the overbody to the underbody. According to another variant, the

25 preferably plate-shaped underbody may also have a plurality of recesses such as grooves, blind holes, recessions, or outwardly extending fins or webs, into which the chilled cast iron material of the overbody engages.

30 However, according to an embodiment of the invention it is also possible to arrange the overbody loosely or substantially loosely upon the underbody or is attached only frictionally thereto. The overbody may be a separate plate and

35 attached to the underbody by fixing means. Such a connection between underbody and overbody may be effected e.g., by welding (directly or indirectly), screwing, soldering (hard soldering), sticking, sintering, or by pressing by means of

40 straps or the like.

45 Where the bombardment-proof object is realised as a combination of tenacious underbody and chilled cast iron overbody, the discovery that the underbody, e.g. an underplate, must be very firm, indeed virtually unyielding, is particularly important. At the same time however, it should not possess the brittleness and great hardness of the overbody, so that the underbody is best described as a "tenacious" material. Without the

50 rear bracing by a tenacious underbody, the brittle and hard overbody would have to be made considerably thicker in order to be able to absorb the impact of the projectile striking it. Due to the flexural stress by the incident projectile, without

55 rear bracing there would be a danger that the overbody, which in conformity with its great hardness is also extremely brittle, might immediately burst into a large number of fragments. But where the overbody is braced by a

60 correspondingly tenacious underbody it has been

65

discovered unexpectedly that the overbody, even if only of moderate thickness, is capable of withstanding a comparatively intense bombardment stress.

70 It is clear from the above statements that it is preferable that the overbody rests upon the underbody directly, substantially without the formation of spaces therebetween. Sagging of the underbody upon the impact of the projectile is thus reliably prevented.

75 Advantageously a thermally insulating layer made preferably of plastics material is arranged between, in front of or behind the underbody of the overbody. Such a composite body affords excellent protection not only against bombardment, but also against thermic destruction, e.g. in the case of the application of heat by a gas flame. This makes it possible for the bombardment proof body to be applied to the protection of installations, the documentary content of which must not be destroyed by the effect of heat.

80 However, the bombardment-proof object according to the invention affords not only an excellent individual and long-term resistance to bombardment, but also, furthermore, safety from other forms of mechanical destruction, e.g. by sawing, drilling, or similar methods.

85 According to a further proposal of the invention, effective protection against the destructive action of explosive charges may be achieved by producing a coating of an elastomer on the surface exposed to bombardment.

90 The underbody may consist of a material having a tensile strength greater than 800 N/mm², e.g., of fine-grain structural steels, or greater than 1500 N/mm², e.g. of martensitically ageing steels (Maraging steels) or of other ageing steel alloys. Thus the underbody may consist of a

95 martenitic material of low carbon content, high nickel content and intermediate cobalt content. The underbody may alternatively consist of a chrome-nickel steel or hard manganese steel.

100 However, the production of the underbody from a high-strength steel does not constitute the sole possibility. On the contrary, it may also be advantageous, more particularly from considerations of the requirement of low weight, to produce the underbody of aluminium or an

105 aluminium alloy, or of plastics material or fibreglass material.

110 Where the overbody is produced from chilled cast iron material, it is recommended to use for this purpose (subject to the condition of adequate flexural strength of the underbody) a material of maximum hardness, preferably having a Vickers hardness (HV 10) of greater than 500. The chilled cast iron may have the following composition:

115 2—6% by weight carbon
120 0—10% by weight chromium
0—10% by weight nickel
0—4.0% by weight silicon
0—20% by weight manganese
0—10% by weight molybdenum
125 130 the balance being iron and trace elements.

Alternatively the chilled cast iron may have the following composition:

1.5—12% by weight carbon
1—40% by weight chromium
5 0—10% by weight nickel
0—4% by weight silicon
0—20% by weight manganese
0—10% by weight molybdenum
0—5% by weight copper

10 the balance being iron.

Another possibility is that the chilled cast iron material contains one or more of niobium, titanium, tungsten, vanadium and molybdenum. Here again, the underlying idea is the

15 incorporation of extremely hard alloy components (e.g. tungsten) in a relatively soft basic mass.

Each surfacing layer may be composed of a plurality of juxtaposed band-shaped layers.

In one embodiment the joint between each 20 adjacent band-shaped layers of one surfacing layer is masked by a band-shaped layer of the surfacing layer thereover.

Preferably, the band-shaped layers forming one surfacing layer are inclined with respect to the

25 band-shaped layers forming the surfacing layer thereover.

According to a further highly advantageous embodiment of the invention, the bombardment-proof object may include at least one tenacious 30 relatively thick base plate and at least one relatively hard surfacing layer of great hardness placed thereover. In this case the base plate may consist of a weldable rolled steel. The surfacing layer may consist of a carbide-forming material

35 with a macro-hardness of over 550 Vickers units, preferably over 600 Vickers units. The surfacing layer preferably consists of a material with 3 to 5% by weight carbon, 20 to 35% by weight chromium, the balance being iron. The surfacing

40 layer may have the following composition:

4—6% by weight C
20—30% by weight Cr
5—8% by weight Nb
5—8% by weight Mo
45 1—3% by weight W

the balance being iron and trace elements.

An outer edge of the bombardment-proof object only may be provided with the surfacing layer.

The surfacing layer may have a thickness of 4 to 6 50 mm.

In this embodiment of the invention the resistance to bombardment is substantially guaranteed by the hard surfacing layer, whereas the base plate only serves as a support element

55 for the surfacing layer. No high-grade alloy material whatsoever is necessary for the base plate, which contributes substantially to a reduction of costs. Since even relatively thin surfacing layers of hard material produce high

60 resistance to penetration, the overall weight can be kept low. The resistance to bombardment can

also be increased virtually at will by applying a plurality of surfacing layers on the base plate. Thus the surfacing layers applied to the base plate

65 may have different hardness from one another.

The outmost surfacing layers may consist of a relatively soft material with a macro-hardness of less than 300 Vickers e.g. chrome-nickel steel.

According to another embodiment of the

70 invention it is also possible to compose the bombardment-proof object of a plurality of loose individual plates placed together with an interstice, whilst each individual plate comprises a tenacious base plate with a harder surfacing layer present thereon.

Whereas the known armour plates are not very suitable for load-bearing functions due to their alloy composition, which is aimed solely at resistance to bombardment, it is immediately

80 possible with the hard surfaced armour plate according to the invention, for the entire bombardment-proof object to be self-supporting by appropriate choice of the material of the base plate and suitable dimensioning of the same. By

85 this means the support structures which are otherwise necessary can be economised, which contributes advantageously to a considerable reduction in weight of the entire installation to be armoured.

90 Alternatively, the bombardment-proof object may include fixing means for fixing to a bracing support structure. The fixing means may enable the bombardment-proof object to be screwed onto a bracing support structure. Preferably

95 points of attachment between the bombardment-proof object and the bracing support structure are protected by a relatively extremely hard layer. The fixing means may be stay bolts and/or screwthreaded bushings cast into the chilled cast

100 iron material. Alternatively, the fixing means are dovetail-shaped grooves into which corresponding parts of the bracing support structure engage. Wedges may be included for tensioning with the bracing support structure.

105 A further considerable advantage of such a bombardment-proof object lies in the fact that its resistance to bombardment can be varied locally in simple manner, for which the hard surfacing layer need only be chosen thicker or thinner in the

110 relevant parts. The bombardment-proof object or a part may thus be thicker in regions which are arranged to be exposed to a particularly intense stress than in other regions.

According to a further aspect of the present

115 invention there is provided a method of producing a bombardment-proof object as recited above in which the surfacing layer or layers is/are applied pendulum fashion by hard surfacing. The hard surfacing should preferably be performed with

120 filled tubular wire.

As a further development of the above-mentioned method according to the invention, it is proposed that an unalloyed or alloyed electrified wire is guided pendulum fashion in 125 parallel tracks and with forward movement over the base plate a quantity regulated as a function

of the wire feed, of pulverous alloyed welding material being introduced continuously into the region of an arc.

The hard surfacing may be performed in such a way that juxtaposed band-shaped layers are applied consecutively.

The overbody may extend laterally of the underbody so that the lateral surfaces of the underbody have a chilled cast iron material thereon.

The hardness ratio of the underbody to the overbody preferably is 1:2.5 to 1:5.

In one embodiment, the underbody is plate-shaped with a minimum thickness of 1.5 mm.

15 The chilled cast iron material may be corrugated on its surface which is arranged to be exposed to bombardment or of domed construction.

20 The bombardment-proof object may be composed of a plurality of superposed individual plates, each comprising underbody and overbody.

The outer edge of the underbody may be only partially covered by the overbody.

25 Preferably the ratio of the thickness of the underbody to the thickness of the overbody is at least 3:1 in the case of one overbody, and at least 3:2 in the case of two superposed overbodies.

The overbody may be applied on the underbody by explosion welding.

30 The invention is illustrated, merely by way of example, in the accompanying drawings, in which:

Figure 1 is a sectional view of a single-layered bombardment-proof object according to the present invention fixed by screws on a bracing support structure;

Figure 2 is a plan view of the arrangement of Figure 1;

Figures 3 and 4 show, in section, other 40 embodiments of the fixing of bombardment-proof objects according to the present invention upon a support structure;

Figure 5 shows, in cross-section, a further way of fixing a bombardment-proof object according to the present invention upon a support structure;

Figure 6 shows the arrangement of Figure 1 in side elevation;

Figure 7 illustrates another embodiment of a bombardment-proof object according to the present invention in section;

Figure 8 shows a further embodiment of a bombardment-proof object according to the present invention and incorporating tungsten carbide elements;

55 Figure 9 shows a curved bombardment-proof object according to the present invention with thin steel inlays for clamping;

Figure 10 shows, in cross-section, another embodiment of a plate-shaped bombardment-proof object according to the present invention in which an overbody (overplate) is cast directly upon an underbody (underplate);

60 Figure 11 shows another embodiment of a plate-shaped bombardment-proof object

65 according to the present invention with a cast-on

chilled cast iron material layer as a top plate, Figure 11 being a view corresponding to Figure 9;

Figure 12 shows a further embodiment of a plate-shaped bombardment-proof object 70 according to the present invention wherein an overplate consisting of chilled cast iron material is of corrugated construction and engages into root-like depressions of an underplate;

Figure 13 shows a bombardment-proof object 75 according to the present invention composed of a plurality of underplate/overplate combinations;

Figure 14 shows, schematically in plan, an embodiment of a bombardment-proof object according to the present invention with a hard 80 surface layer;

Figure 15 shows the bombardment-proof object of Figure 14 in cross-section;

Figure 16 shows a further embodiment of a bombardment-proof object according to the 85 present invention in cross-section;

Figure 17 shows another embodiment of a bombardment-proof object according to the present invention in cross-section;

Figure 18 shows the bombardment-proof 90 object of Figure 15 in the assembled position; and

Figure 19 shows a further example of assembly of bombardment-proof objects according to the present invention.

As shown in Figures 1 ad 2, reference numeral 95 10 designates a bracing support structure, e.g. the wall of a vehicle which is required to be armoured. But the support structure 10 may also be—as indicated by dash lines in Figure 2—a framewise support structure.

100 Fixed on the support structure 10 there is a single-layered bombardment-proof object 11 according to the present invention made of chilled cast iron which is composed of a plurality of individual plates 14, 15, 16 butt-jointed together at 12, 13 respectively. Obviously this is merely an example, i.e. it is also conceivable to fix the bombardment-proof object 11 in the form of a single continuous plate on the support structure 10. On the other hand it is also conceivable to

110 divide the bombardment-proof object 11 into even smaller individual plates than shown and to join any desired number of such individual plates together.

As is clear, more particularly from Figure 1, and 115 as is illustrated by the individual plate 14, a plurality of stay bolts 17 are cast into the bombardment-proof object 11 and have a screw-thread 18 on the portion projecting beyond the chilled cast iron material. The stay bolts 17 penetrate corresponding bores in the support structure 10. The fixing of the support structure 10, and the bombardment-proof object 11 is then effected by means of nuts 19 screwed onto the bolts 17.

120 As Figure 1 further shows, other forms of releasable attachment of the support structure 10 and the bombardment-proof object 11 may be employed as an alternative to or additional to that illustrated. For this purpose, screwthreaded bushings 20 made of steel may be cast into the

125

bombardment-proof object 11. Stay bolts 21 may then be screwed from beneath into the female screwthread of these bushings 20.

Figure 3 shows another type of releasable attachment between the bombardment-proof object 11 and the support structure 10. For this purpose grooves 22 of T-shaped cross-section are cast into the bombardment-proof object 11. Stay bolts 23 are slid laterally into the grooves 22 and then screwed to the support structure 10 by means of the nuts 19 similarly to the embodiment shown in Figures 1 and 2. It is possible, by bushing-like distance pieces 23, to create between the bombardment-proof object 11, and the support structure 10 an interstice which may be packed e.g. with thermally and/or sonically insulating material.

In the embodiment shown in Figure 4 the bombardment-proof object 11 has a shouldered continuous recess 24 through which a screw bolt 25 is plugged from the outside. However, in contra-distinction to the embodiments described hereinbefore, the screw bolt 25 likewise exhibits an armouring of chilled cast iron material on its end 27 upon a surface 26 otherwise exposed to bombardment. A weakening of the bombardment resistance of the bombardment-proof object 11 where it is connected to the support structure 10 is avoided in this way.

Figures 5 and 6 show a positive attachment between the bombardment-proof object 11 and the support structure 10. For this purpose a dovetail groove 28 is cast into the bombardment-proof object 11, which cooperates with a corresponding counterpiece 29 on the support structure 10. The necessary differences in size of the groove 28 and counterpiece 29 are then compensated by wedges 30 driven in laterally.

A further possibility of fixing the bombardment-proof object 11 to a bracing support structure (not shown) is indicated in Figure 7. For this purpose a thin perforated plate 31 made of steel is cast onto the bombardment-proof object 11. By means of the perforated plate 31, the entire bombardment-proof object 11 can be welded onto a support structure. In contrast to the embodiments shown in Figures 1 to 6 and described hereinbefore, this is a non-releasable attachment between the bombardment-proof object and the support structure.

Figure 8 shows the bombardment-proof object 11 with tungsten carbide particles 32 incorporated therein for armouring purposes. The extreme hardness of the tungsten carbide particles 32 produces an increase in the bombardment resistance.

The embodiment of the present invention shown in Figure 9 shows a further peculiarity, steel inlays 33 being cast into the chilled cast iron material of the bombardment-proof object 11. The steel inlays 33 are of rod-like construction and are kept movable within narrow limits with respect to the chilled cast iron material. Their total weight is less than 5%, preferably less than 0.5%, of the total weight of the bombardment-proof

object 11. The steel inlays 33 serve to clamp the chilled cast iron material, in such a way that when a breach has already occurred, the latter does not fragment into numerous individual pieces, but the fragments are, on the contrary, still held together by the steel inlays 33. As Figure 9 shows, the steel inlays 33 are arranged as far as possible away from a surface 34 of the bombardment-proof object 11 which is exposed to bombardment, so as to impair its bombardment resistance as little as possible.

It is obviously also possible to provide steel inlays 33 in order to clamp the bombardment-proof object 11 in the embodiments illustrated and described hereinbefore.

Figure 10 shows a bombardment-proof object consisting of an underbody or underplate 110 of tenacious metallic material and a chilled cast iron material plate 111 fixed thereon as overbody or overplate. The underplate 110 is of sieve-like construction and has holes 112. When liquid chilled cast iron material is poured onto the underplate 110, the chilled cast iron material—as shown—penetrates into the holes 112 and thereby produces a particularly firm attachment between under plate 110 and the overplate 111.

In the embodiment of the present invention shown in Figure 11 an underplate 113 is of unperforated construction. A layer 114 of chilled cast iron material is cast directly onto the underplate, whilst lateral surfaces 115 of the underplate 113 are cast round with chilled cast iron material. By this means, firstly a good joint is formed between the underplate 113 and the layer 114, and secondly a bombardment resistance is also produced on the lateral surfaces 115 of the underplate 113.

A further peculiarity of the embodiment shown in Figure 11 (which may however obviously also be taken into consideration in the other embodiments illustrated) consist in that rod-shaped steel inlays 116 are cast into the layer 114. The steel inlays 116 are kept movable within narrow limits with respect to the chilled cast iron material. Their total weight is less than 5%, preferably less than 0.5%, of the total weight of the layer 114. The steel inlays 116 serve to clamp the layer 114 in such a way that, when a breach has already occurred, the latter does not fall apart into numerous individual pieces, but fragments are held together by the steel inlays 116. The steel inlays 116 are arranged as close as possible to the surface of the underplate 113 so as to impair the bombardment resistance of the chilled cast iron material layer 114 as little as possible.

In the embodiment of the present invention illustrated in Figure 12, a chilled cast iron overbody 117, has a corrugated surface. Again in this embodiment, the overbody 117 may, in principle, be cast directly onto the underplate 113. Recesses 130 in the underbody 113 serve as housings for root elements 131 of the overbody 117. The recesses 130 may be formed, for example, as grooves, holes, recessions etc., or 130 may be formed by webs extending outwardly. It

may further be seen from Figure 12 that the recesses 130 and the root elements 131 each lie in the places where there are troughs in the corrugated surface of the overbody 117. By this means any weakening, or any reduction of the bombardment resistance, of the overbody 117 at these points is advantageously obviated.

However, in order to form the corrugated surface of the overbody 117, a separate production thereof may also be convenient. The separate overbody 117—without root elements in this case—can then be attached subsequently to the underplate 113 by screwing, welding, soldering, glueing or by a clamp connection.

As Figure 12 illustrates, the corrugated surface of the overbody 117 is designed to immediately deflect an incident projectile 118 sideways as shown by arrows 119, 120, so as to reduce the destructive effect.

Figure 13 shows a bombardment-proof object according to the present invention which is composed of two individual compound plates 128, 129. Each compound plate consists of a respective underplate 124, 125 and of a respective extremely hard overplate 126, 127 fixed thereon. The overplates 126, 127 are preferably cast directly onto the respective underplates 124, 125. The individual compound plates 128, 129 thus produced may be laid loosely on one another or joined together, for example, by screws or straps.

The wall thickness a of the underplate 125 may be in a ratio of approximately 1:1 to 1:0.4 to the wall thickness b of the overplate 127 in order to ensure the desired rigidity of the underplate. Obviously, this wall thickness ratio does not apply only to the embodiment shown in Figure 13, but may also to the other embodiments of the present invention illustrated and described herein. The ratio of the hardness of the underplate to the hardness of the overplate may be approximately 1:2.5 to 1:5, whilst a material with a Vickers hardness (HV 10) in excess of 500 should be used for the overplate.

According to each of the Figures 14 to 16, 18 and 19 a bombardment-proof object according to the present invention in the form of an armoured plate exhibits a single base plate 210 made of tenacious material, preferably of a weldable rolled steel. On the base plate 210 and firmly attached thereto is a surfacing layer 211 of a material of great hardness which is of single-layered construction in the embodiments according to Figures 14, 15, 18 and 19. As is clear more particularly from Figures 15, 18 and 19, the hard surfacing layer 211 does not consist of a coherent and continuous coating, but rather of individual tracks 212 which are juxtaposed. The respective joint width between two adjacent hard surfacing tracks 212 in this case may vary from zero up to a given interval—depending upon the purpose of use.

The application of the hard surfacing layer 211 is effected—as shown in Figure 14—by automatic hard surfacing, in which the wire feed

device and the arc—as indicated by meander lines in Figure 14—execute a pendulum movement in known manner. The amplitude of this pendulum movement then corresponds to the width of each track 212.

But the hard surfacing layer 211 on the base plate 210 is not necessarily a single layer. As shown in Figure 16 two superposed hard surfacing layers 211a, 211b are provided. The hard surfacing layer 211b in this case is applied so that a joint line 213a extending between the two surfacing tracks 212a of the hard surfacing layer 211a is covered in each case by a surfacing track 212b of the hard surfacing layer 211b.

Optimum bombardment resistance is ensured by this means.

As indicated by dash lines in Figure 16, yet a third hard surfacing layer 211c may be provided over the hard surfacing layer 211b. This

outermost hard surfacing layer 211c conveniently consists of a relatively soft material having a macro-hardness less than 300 Vickers, e.g. chrome-nickel steel. By this means the impact of projectile upon the hard surfacing layers 211a, 211b therebeneath is attenuated. Furthermore, the hard surfacing layer 211c acts as an anti-corrosion means.

A further embodiment of a bombardment-proof object or armoured plate according to the present invention is illustrated in Figure 17. Two superposed base plates 210a, 210b are each coated with a hard surfacing layer 214a, 214b respectively. The two individual base plates, each consisting of base plate and hard surfacing layer, are in this case placed together loosely but not fixed together. This embodiment has a particular good damping effect upon the impact of projectiles.

As a rule a single armoured plate of the type illustrated will not have a sufficient large surface to armour adequately the object which is to be protected, e.g. a vehicle. It is therefore necessary for a plurality of armoured plates to be joined together. Figure 15 shows by way of example an

arrangement whereby the individual armoured plates are placed together with butt joints and are each welded together at the underside of the base plate 210. The relevant weld positions are indicated by dash lines in Figure 15 and designated by the reference numeral 215. On the top side of a joint line 216 produced between two mutually adjacent armoured plates, a hard surfacing layer 217 masking the same is applied in order to protect the joint line between two armoured plates. The hard surfacing layers 217 conveniently consist of the same hard surfacing material as the tracks 212.

Figure 18 illustrates the fixing of the armoured plates to the object to be protected, e.g. to the external walls of a vehicle. For this purpose the edges of the armoured plate, which are free of hard surfacing layers, have passageways 218 which are penetrated by screws 219. The continuous bracing support structure therebeneath is designated by the reference

numeral 220. In order to protect from bombardment joints between the passageways 218 and screws 219 with the support structure 220, the external heads of the screws 219 are 5 also provided with a hard surfacing 221 of material. The armoured plate used in the embodiment according to Figure 18 need not be self-supporting, because the support functions are performed by the support structure 220 located 10 beneath it.

In the embodiment illustrated in Figure 19, however, self-supportingly constructed armoured plates are used. The latter are each braced solely by their edges on girders 222 of I-shaped cross-section which are arranged at comparatively wide spacing and thus form a grid-like support skeleton. Here again the fixing of the armoured plates to the girders 222 may be effected—as in the embodiment shown in Figure 18—by screws 20 223 which are indicated by chain dotted lines. However, it is obviously also conceivable to fix the armoured plates to the support structure located therebeneath by welding or otherwise joining.

Claims

25 1. A bombardment-proof object, consisting totally or partially of chilled cast iron material.
 2. A bombardment-proof object as claimed in claim 1, composed of a plurality of individual members consisting totally or partially of chilled 30 cast iron material butt-jointed together.
 3. A bombardment-proof object as claimed in claim 1 or 2, of single-layered construction.
 4. A bombardment-proof object as claimed in any preceding claim consisting preponderantly of 35 chilled cast iron.
 5. A bombardment-proof object as claimed in claim 1 or 2 or claim 4 when dependent thereon consisting of two or more superposed layers.
 6. A bombardment-proof object as claimed in 40 claims 2 and 5, in which joints between individual members of one layer are staggered with respect to joints between individual members of the layer placed thereover and/or thereunder.
 7. A bombardment-proof object as claimed in 45 claim 5 or 6, in which the superposed layers are attached to one another.
 8. A bombardment-proof object as claimed in any of claims 5 to 7 including a tenacious underbody and an overbody of chilled cast iron 50 thereon.
 9. A bombardment-proof object as claimed in claim 8 in which the overbody is arranged loosely or substantially loosely upon the underbody or is attached only frictionally thereto.
 55 10. A bombardment-proof object as claimed in claim 8 in which the overbody is attached to the underbody over its entire surface of contact, so that the two parts form a composite object:
 11. A bombardment-proof object as claimed in 60 claim 10 in which the chilled cast iron material

forming the overbody is fixed on the underbody directly by casting.

12. A bombardment-proof object as claimed in claim 11 in which the underbody is a perforated plate, the surface of the underbody and the holes therein into which the cast chilled cast iron material penetrates, fix the overbody to the underbody.
13. A bombardment-proof object as claimed in 70 claim 9, in which the overbody is a separate plate attached to the underbody by fixing means.
14. A bombardment-proof object as claimed in claim 13 in which the overbody is welded indirectly to the underbody.
15. A bombardment-proof object as claimed in 75 claim 13 in which the overbody is screwed into the underbody.
16. A bombardment-proof object as claimed in claim 13 in which the overbody is attached to the 80 underbody by soldering.
17. A bombardment-proof object as claimed in claim 13 in which the overbody is glued onto the underbody.
18. A bombardment-proof object as claimed in 85 claim 13, in which the overbody is attached to the underbody by sintering.
19. A bombardment-proof object as claimed in claim 13 in which the overbody is attached to the underbody by straps.
20. A bombardment-proof object as claimed in 90 any of claims 5 to 19 in which a thermally insulating intermediate layer is arranged between, in front of or behind the underbody and the overbody.
21. A bombardment-proof object as claimed in 95 any of claims 8 to 14 in which the overbody rests upon the underbody directly substantially without the formation of spaces therebetween.
22. A bombardment-proof object as claimed in 100 any of claims 8 to 21 in which the underbody consists of a material having a tensile strength greater than 800 N/mm².
23. A bombardment-proof object as claimed in claim 22 in which the underbody consists of a 105 martensitic material of low carbon content, high nickel content and intermediate cobalt content.
24. A bombardment-proof object as claimed in claim 22 in which the underbody consists of a chromium-nickel steel.
25. A bombardment-proof object as claimed in 110 any of claims 8 to 21 in which the underbody consists of aluminium or an aluminium alloy.
26. A bombardment-proof object as claimed in any of claims 8 to 21 in which the underbody 115 consists of plastics material or fibreglass material.
27. A bombardment-proof object according to one or more of the foregoing as claimed in any preceding claim in which the chilled cast iron material has a Vickers hardness (HV 10) greater than 500.
28. A bombardment-proof object as claimed in

- any preceding claim in which the chilled cast iron has the following composition:
- 2—6% by weight carbon
0—10% by weight chromium
0—10% by weight nickel
0—4.0% by weight silicon
0—20% by weight manganese
0—10% by weight molybdenum
the balance being iron and trace elements.
- 10 29. A bombardment-proof object as claimed in any of claims 1 to 27 in which the chilled cast iron material has the following composition:
- 1.5—12% by weight carbon
1—40% by weight chromium
0—10% by weight nickel
0—4% by weight silicon
0—20% by weight manganese
0—10% by weight molybdenum
0—5% by weight copper
20 the balance being iron.
- 30 30. A bombardment-proof object as claimed in any of claims 1 to 27 in which the chilled cast iron material contains one or more or niobium, titanium, tungsten, vanadium and molybdenum.
- 25 31. A bombardment-proof object as claimed in any preceding claim in which granules and/or inserts of tungsten carbide are incorporated in the chilled cast iron material.
32. A bombardment-proof object as claimed in any preceding claim including rod-shaped steel inlays located movably within the chilled cast iron material, the total weight of the said inlays being less than 5% of the total weight of the chilled cast iron material, and cast into the chilled cast iron material.
33. A bombardment-proof object as claimed in claim 32, in which the steel inlays are arranged within the chilled cast iron material remote from the surface arranged to be exposed to bombardment.
- 40 34. A bombardment-proof object as claimed in claim 8 or any of claims 9 to 33 when dependent thereon in which the overbody extends laterally of the underbody so that the lateral surfaces of the underbody have a chilled cast iron material thereon.
- 35 35. A bombardment-proof object as claimed in claim 8 or any of claims 9 to 34 when dependent thereon in which the hardness ratio of the underbody to the overbody is 1:2.5 to 1:5.
36. A bombardment-proof object as claimed in claim 8 or any of claims 9 to 35 when dependent thereon in which the underbody is plate-shaped with a minimum thickness of 1.5 mm.
- 55 37. A bombardment-proof object as claimed in any preceding claim in which the chilled cast iron material is corrugated on its surface which is arranged to be exposed to bombardment.
38. A bombardment-proof object as claimed in any preceding claim in which the chilled cast iron material is of domed construction.
39. A bombardment-proof object as claimed in any preceding claim which or a part of which is thicker in regions which are arranged to be exposed to a particularly intense stress than in other regions.
- 60 40. A bombardment-proof object as claimed in any preceding claim of self-supporting construction.
- 70 41. A bombardment-proof object as claimed in any preceding claim including fixing means for fixing to a bracing support structure.
42. A bombardment-proof object as claimed in claim 41 in which the fixing means enable the bombardment-proof object to be screwed onto a bracing support structure.
- 75 43. A bombardment-proof object as claimed in claim 41 or 42 in which points of attachment between the bombardment-proof object and the bracing support structure are provided by a relatively extremely hard layer.
44. A bombardment-proof object as claimed in any of claims 41 to 43 in which the fixing means are stay bolts and/or screwthreaded bushings cast into the chilled cast iron material.
- 80 45. A bombardment-proof object as claimed in any of claims 41 to 43 in which the fixing means are dovetail-shaped grooves into which corresponding parts of the bracing support structure engage.
46. A bombardment-proof object as claimed in claim 45 including wedges for tensioning with the bracing support structure.
- 90 47. A bombardment-proof object as claimed in any of claims 8, 10 12, 21—24, 34—36, 38, 43, including at least one tenacious relatively thick base plate and at least one relatively hard surfacing layer of great hardness placed thereover.
- 100 48. A bombardment-proof object as claimed in claim 47 in which the base plate consists of a weldable rolled steel.
49. A bombardment-proof object as claimed in claim 47 or 48 in which the surfacing layer consists of a carbide-forming material with a macro-hardness of more than 550 Vickers units.
- 105 50. A bombardment-proof object as claimed in claim 49 in which the surfacing layer consists of a material with 3 to 5% by weight carbon, 20 to 35% by weight chromium, the balance being iron.
51. A bombardment-proof object as claimed in claim 49 in which the surfacing layer has the following composition:
- 115 4—6% by weight C
20—30% by weight Cr
5—8% by weight Nb
5—8% by weight Mo
1—3% by weight W
the balance being iron and trace elements
- 120 52. A bombardment-proof object as claimed in any of claims 47 to 51 in which a plurality of said surfacing layers are applied on the base plate.
53. A bombardment-proof object as claimed in claim 52 in which the surfacing layers applied on the base plate have different hardness from one another.

54. A bombardment-proof object as claimed in claim 52 or 53 in which the outermost surfacing layers consists of a relatively soft material with a macro-hardness of less than 300 Vickers.
- 5 55. A bombardment-proof object as claimed in any of claims 8 to 54 composed of a plurality of superposed individual plates, each comprising underbody and overbody.
- 10 56. A bombardment-proof object as claimed in any of claims 8 to 55 in which the outer edge of the underbody is only partially covered by the overbody.
- 15 57. A bombardment-proof object as claimed in any of claims 8 to 56, in which the ratio of the thickness of the underbody to the thickness of the overbody is at least 3:1 in the case of one overbody, and at least 3:2 in the case of two superposed overbodies.
- 20 58. A bombardment-proof object as claimed in claim 47 or any of claims 48 to 57 when dependent thereon having an outer edge only partially provided with the surfacing layer.
- 25 59. A bombardment-proof object as claimed in claim 47 or any of claims 48 to 58 when dependent thereon in which each surfacing layer has a thickness of 4 to 6 mm.
- 30 60. A bombardment-proof object as claimed in claim 47 or any of claims 48 to 59 when dependent thereon in which each surfacing layer is composed of a plurality of juxtaposed band-shaped layers.
- 35 61. A bombardment-proof object as claimed in claim 60 in which the joint between each adjacent band-shaped layers of one surfacing layer is masked by a band-shaped layer of the surfacing layer thereover.
- 40 62. A bombardment-proof object as claimed in claim 60 or 61 in which the band-shaped layers forming one surfacing layer are inclined with respect to the band-shaped layers forming the surfacing layer thereover.
63. A bombardment-proof object as claimed in claim 8 in which the overbody is applied on the underbody by explosion welding.
- 45 64. A bombardment-proof object as claimed in claim 11 in which the underbody has a plurality of recesses into which the chilled cast iron material of the overbody engages.
- 50 65. A bombardment-proof object as claimed in any preceding claim including a coating of an elastomer on the surface exposed to bombardment.
- 55 66. A plurality of bombardment-proof objects as claimed in any preceding claim braced solely at their edges on a skeleton support structure.
- 60 67. A plurality of bombardment-proof objects as claimed in any preceding claim are arranged with butt joints therebetween and are braced upon a support structure to which they are fixed.
- 65 68. A method of producing a bombardment-proof object as claimed in claim 47, in which the surfacing layer or layers is/are applied pendulum fashion by hard surfacing.
- 70 69. A method as claimed in claim 68 in which the hard surfacing is performed with filled tubular wire.
- 75 70. A method as claimed in claim 68 or 69 in which an unalloyed or alloyed electrified wire is guided pendulum fashion in parallel tracks and with forward movement over the base plate in a quantity regulated as a function of the wire feed, of pulverous alloyed welding material being introduced continuously into the region of an arc.
- 80 71. A method as claimed in claim 68 to 70 in which hard surfacing is performed in such a way that juxtaposed band-shaped layers are applied consecutively.
72. A bombardment-proof object substantially as herein described with reference to and as shown in the accompanying drawings.